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(54) **Engine induction air cooling**

(57) A cooling system for a liquid-cooled turbocharged internal combustion engine (1) comprises means for cooling of the engine induction air charge by means of a liquid-air intercooler (7). Collant for cooling of the air charge by the intercooler (7) is initially further cooled in an auxiliary circuit, which branches off from the main cooling circuit of the engine (1) downstream of a pump (2), by passing through an auxiliary cooler (6).

Fig.1.

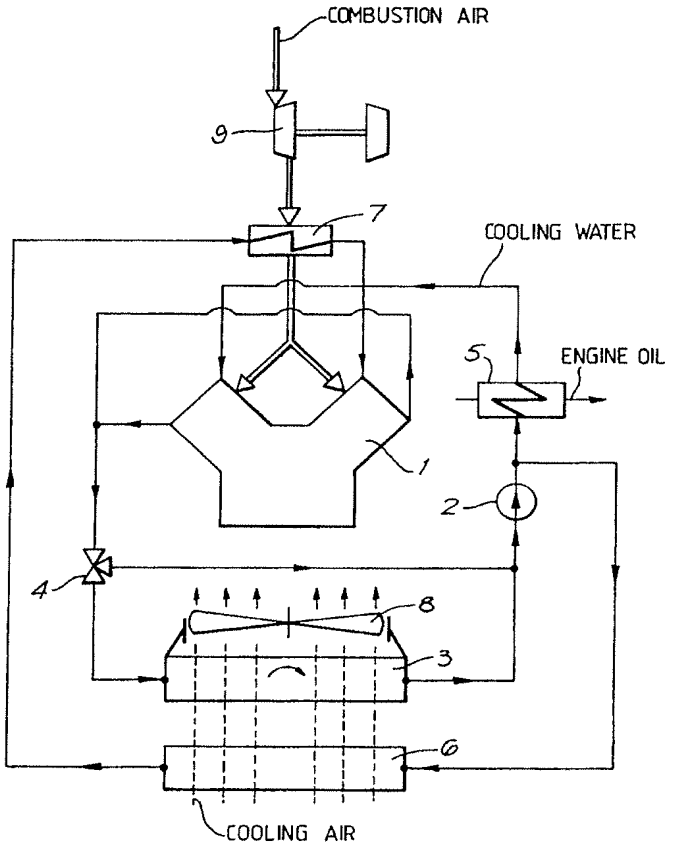

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Fig.1.

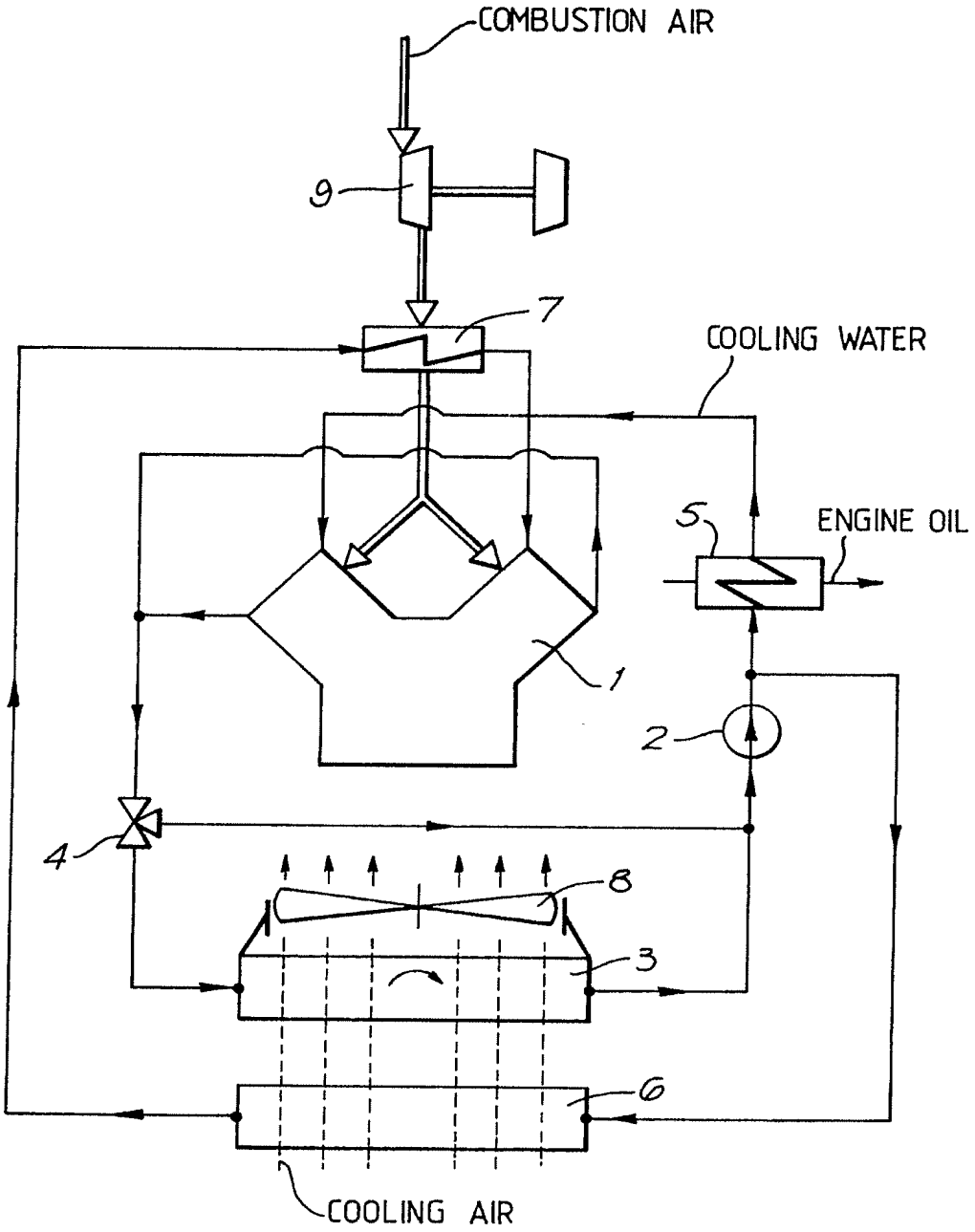
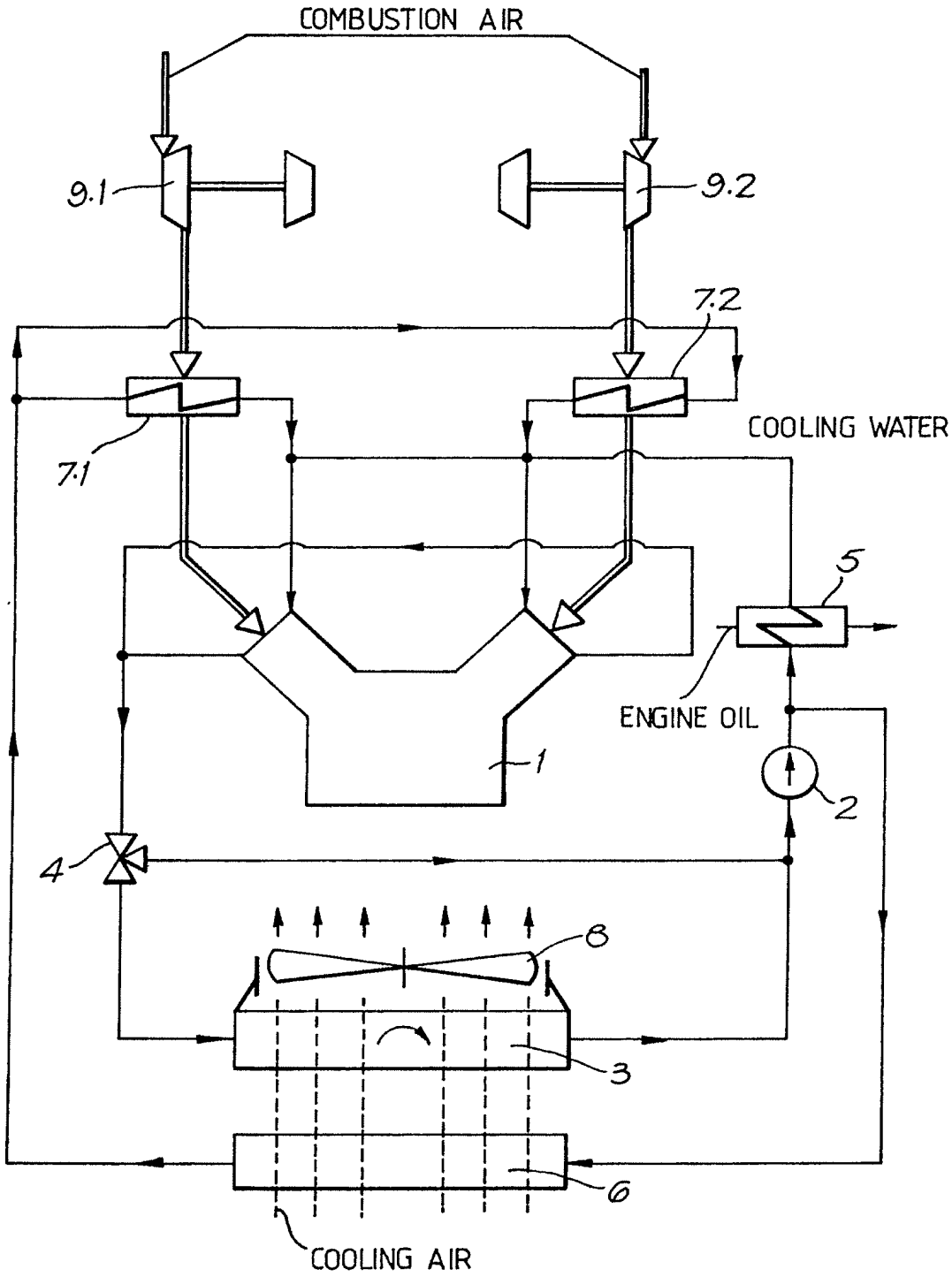

COMBUSTION AIR
9
7
COOLING WATER
5
ENGINE OIL
1
2
4
8
3
6
COOLING AIR

Fig.2.


COMBUSTION AIR
9.1
9.2
7.2
7.1
COOLING WATER
5
ENGINE OIL
1
2
4
8
3
6
COOLING AIR

SPECIFICATION

Engine induction air cooling

The present invention relates to a cooling system for a liquid-cooled turbocharged internal combustion engine with cooling of the induction air charge of the engine.

It is known to increase the output of a forced-induction internal combustion engine by arranging cooling means for reducing the temperature of the air charge before it enters the engine cylinders. This measure, termed induction air cooling or intercooling of the induction air charge, has generally found widespread use and is carried out in three ways, which are distinguished according to the cooling medium and consist of "air-air" cooling where air is used as a direct cooling medium, "air-air" cooling where water is used as a direct coolant, and two stage cooling where water is used, in the first stage and air, as a direct cooling medium, in the second stage.

Among the technical advantages of air-air cooling, in which induction air heated up by compression is cooled in a cooler which in turn is traversed by the ambient air as coolant, is the possibility of cooling the induction air to a relatively low temperature level, close to the ambient temperature, and thus of achieving a high efficiency of the induction air cooling. A drawback is that, depending upon the installation possibilities of the air-air cooler in relation to the engine, induction air ducts of large volume, which require an appreciable amount of space, must be conducted from the tubocharger to the cooler and thence back to the engine. The difficulites in the layout of such ducts and the constructional expense are related to the size of the engine and commensurately increase with larger engines.

A solution to this problem is especailly difficult to find in the case of a V-type engine, as the induction air ducts must be arranged for two rows of cylinders, and in those individual cases where, for reasons of space, it is not possible to arrange the intercooler in the immediate vicinity of the engine. Apart from the space requirement disadvantages, long and cranked air induction ducts lead to flow rate losses, which result in a reduction in the efficiency of the forced induction.

The most commonly encountered solution for the intercooling problem is to dispose an air-air cooler as a separate unit in front of the water cooler with respect to the direction of travel of the automobile or tractor, as the case may be, so that cooling air propelled by the engine fan and travel speed induced air flow passes first through the air-air cooler and thereafter through the water cooler of the cooling system. Such an arrangement is found on, for example, the following types of diesel engines:

- Perkins T 6.3543 GB
- SM D 14 SU

Constructed examples of this arrangement for water-cooled V-type engines are not known, evidently due to the afore-mentioned disadvantage.

In the case of air-water intercooling, in which the heated induction air is cooled in the cooler by water or other form of liquid coolant, the disadvantage of long induction ducts of large volume disappears. Known arrangement of this type are:

- combined diesel engine type SMD 14 (SU) with separate inducation air cooling water circuit, which is driven by a separate, additional water pump and has its own water-air cooler for recooling the cooling water. A disadvantage of this arrangement is the need for an additional water pump.
- marine diesel engine 6 Tsch N 12/14 - SU, in which the source of the cooling water for the induction air cooler is outboard.

In those cases in which a cooling water flow for the cooling of the induction air is fully integrated into the cooling circuit of the engine, the induction air can only be cooled down to a relatively high temperature level, dependent on the cooling water temperature of this circuit, with the result that the effectiveness of the inducation air cooling is reduced by comparison with the separate cooling circuit. Disclosed arrangements of this type are

- 6, 8 and 12 cylinder engines of the series 331/396 by the firm MTU (DE) British Patent No. 1 438 775
- Tractor diesel type 404 by the firm John Deere (US).

In order to avoid the disadvantage of this form of cooling, namely the compartively limited scope for significantly lowering the temperature of the inducation air, while at the same time utilizing its advantages, the firm MACK (US) has developed for its diesel engine type 2234 an induction air cooling circuit in which the air is cooled in two stages. The first stage is realized by an intercooler of the air-water type, which is incorporated in the cooling circuit of the engine and in which the induction air is recooled from 170°C. The second stage is realized by an intercooler of the air-air type, in which the induction air is lowered from 104°C to approximately 70°C. The propulsion of the cooling air of this cooler is effected by a fan, which in turn is driven by an air turbine. This is connected to the induction duct and requires a proportion of 7% of the air charge for its drive. The above combined arrangement may be regarded as a third method of cooling.

There is accordingly a need for a method of cooling engine induction air by liquid-air heat exchange with connection of the induction air intercooler to the engine cooling system, while avoiding the disadvantage of a limited cooling effect, such a method serving to increase engine power output with minimum

constructional complication.

According to the present invention there is provided a cooling system for a liquid-cooled turbocharged internal combustion engine, comprising a main cooling circuit including a pump for feeding liquid coolant to the engine for cooling thereof, and an auxiliary cooling circuit for supplying the coolant to a liquid-air intercooler for cooling the engine induction air charge, the auxiliary cooling being connected to the main circuit to draw coolant therefrom downstream of the pump and comprising an auxiliary radiator for further cooling of the coolant from the main circuit before supply to the intercooler.

In a preferred embodiment, one or more such intercoolers, mounted on the engine or constructionally integrated therewith, of the air-water type are incorporated in the cooling system of the engine in such a manner that cooling water for cooling the induction air is branced off from the main cooling water flow after passage through the main radiator and through a water pump. The temperature of the branched-off cooling water is reduced by a second water radiator, acting as an auxiliary radiator, to a level approximating that of the ambient temperature, before it is supplied to the or each intercooler. After flowing through or each intercooler, the cooling water heated up therein is fed, depending on the constructional and functional circumstances, either to the cooling water chambers of the engine or directly to the intake side of the water pump.

In order to make simultaneous use of the cooling air flow delivered by a fan for the cooling of the main radiator, the auxiliary radiator is preferably arranged in thi cooling air flow parallel to and upstream of the main radiator in the direction of the flow. The same applies in the case where a number of main radiators are provided. To take account of specific installation conditions, different arrangements of the auxiliary radiator are also possible, for example alongside the main radiator.

Embodiments of the present invention will now be more particularly described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of an internal combustion engine fitted with a cooling system according to one embodiment of the invention; and

Figure 2 is a schematic diagram of an internal combustion engine fitted with a cooling system according to another embodiment of the invention.

Referring now to the drawings, there is shown in Figure 1 an exhaust turbocharged internal combustion engine having a cooling system which essentially consists of a water pump 2, a main radiator 3 of the water-air type for cooling the cooling water, a cooling water temperature regulator 4, an oil-water heat exchanger 5 and connecting pipework (not shown) of these devices to enable a water flow corresponding to the illustrated connecting lines. These elements constitute a main cooling circuit, which may also include additional devices such as a balancing tank, temperature measurement devices and other such equipment.

The cooling system further comprises a cooling water auxiliary circuit for effecting intercooling of the engine induction air charge, comprising a radiator 6 of the water-air type, an intercooler 7 of the air-water type, and connecting pipework (not shown) which enable a cooling water flow according to the illustrated connecting lines.

After leaving the engine, cooling water already cooled in the main radiator 3 is branched off after passing through the water pump 2 and is conducted into the auxiliary circuit for passage through the auxiliary radiator 6, where it is cooled down to a lower temperature level and then fed to the intercooler 7. After flowing through the intercooler, the water is fed back to the main cooling circuit of the engine.

The cooling of the water in the auxiliary radiator 6 is effected, with a parallel arrangment of main radiator 3 and auxiliary radiator 6, preferably with the same air stream propelled by a fan 8. Nevertheless, other arrangements of the radiators relative to each other are possible as a function of the installation and operating circumstances, and the provision of an additional fan for the auxiliary radiator 6 is also possible.

The cooling of the air charge supplied from a turbocharger 9 is effected in known manner in the intercooler 7, the cooled charge then being supplied to the cylinder of the engine 1.

The embodiment of Figure 2, while retaining the basic principle of main and auxiliary cooling circuits according to Figure 1, shows a variant in which two turbochargers 9.1 and 9.2 are used in combination with two induction air intercoolers 7.1 and 7.2 (analogous also to any number of intercoolers). In this case, cooling water from the auxiliary radiator 6 is supplied in parallel streams to the intercoolers 7.1 and 7.2 in order to provide uniform cooling conditions.

CLAIMS

1. A cooling system for a liquid-cooled turbocharged internal combustion engine, comprising a main cooling circuit including a pump for feeding liquid coolant to the engine for cooling thereof, and an auxiliary cooling circuit for supplying the coolant to a liquid-air intercooler for cooling the engine induction air charge, the auxiliary cooling circuit being connected to the main circuit to draw coolant therefrom downstream of the pump and comprising an auxiliary radiator for further cooling of the coolant from the main circuit before supply to the intercooler.

2. A cooling system as claimed in claim 1, wherein the auxiliary radiator is arranged parallel to a main radiator of the main circuit and upstream of the main radiator with respect to an air flow through the auxiliary and main radiators, single fan means being provided to effect said air flow through both radiators.

3. A cooling system as claimed in either claim 1 or claim 2, wherein the auxiliary circuit is arranged to

supply the coolant in parallel flows to a plurality of such intercoolers and thereafter to feed the coolant to the engine for return to the main circuit.

4. An engine cooling system substantially as hereinbefore described with reference to either Figure 1 or Figure 2 of the accompanying drawings.

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